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Kikkawa et al.

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(54) **MEMORY CONTROLLER**

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(51) **Int. Cl.**

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G06F 12/02	(2006.01)
G06F 3/06	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 12/023*** (2013.01); ***G06F 3/061*** (2013.01); ***G06F 3/0643*** (2013.01); ***G06F 3/0679*** (2013.01); ***G06F 12/0246*** (2013.01); *G06F 2212/1044* (2013.01); *G06F 2212/1048* (2013.01); *G06F 2212/7201* (2013.01)

(58) **Field of Classification Search**

CPC G06F 12/023; G06F 3/0679

See application file for complete search history.

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(57) **ABSTRACT**

A data storage temporarily stores an address conversion table associating the sector numbers with the physical addresses for each file. A conversion table memory allocator allocates a memory region for the address conversion table corresponding to a file when a request is made to open the file. A file system manager releases the allocated memory region at a given time. The file system manager stores sector numbers of one or multiple sectors constituting a file in each record of the address conversion table for which the memory region is allocated in sequence. Then, a memory control section searches the flash memory to acquire a physical address corresponding to a sector number in the each record of the address conversion table, and stores each acquired physical address in the corresponding record.

8 Claims, 7 Drawing Sheets

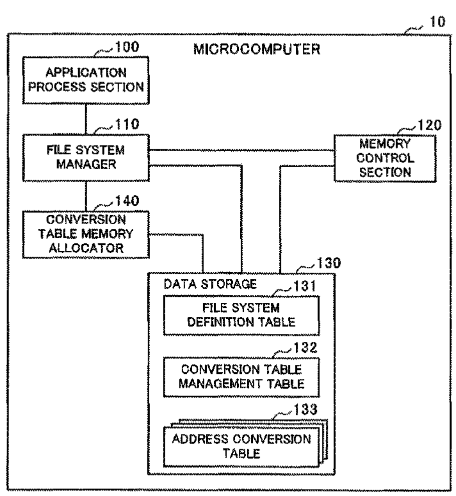

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FIG.1

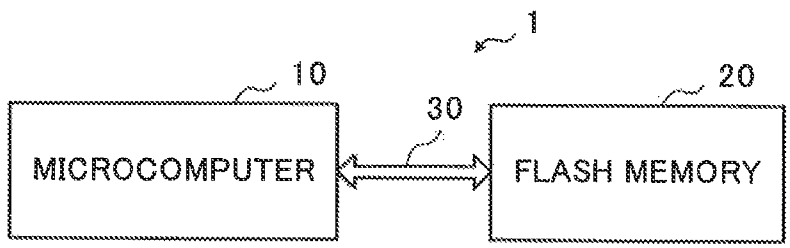
1
10
MICROCOMPUTER
30
20
FLASH MEMORY

FIG.2

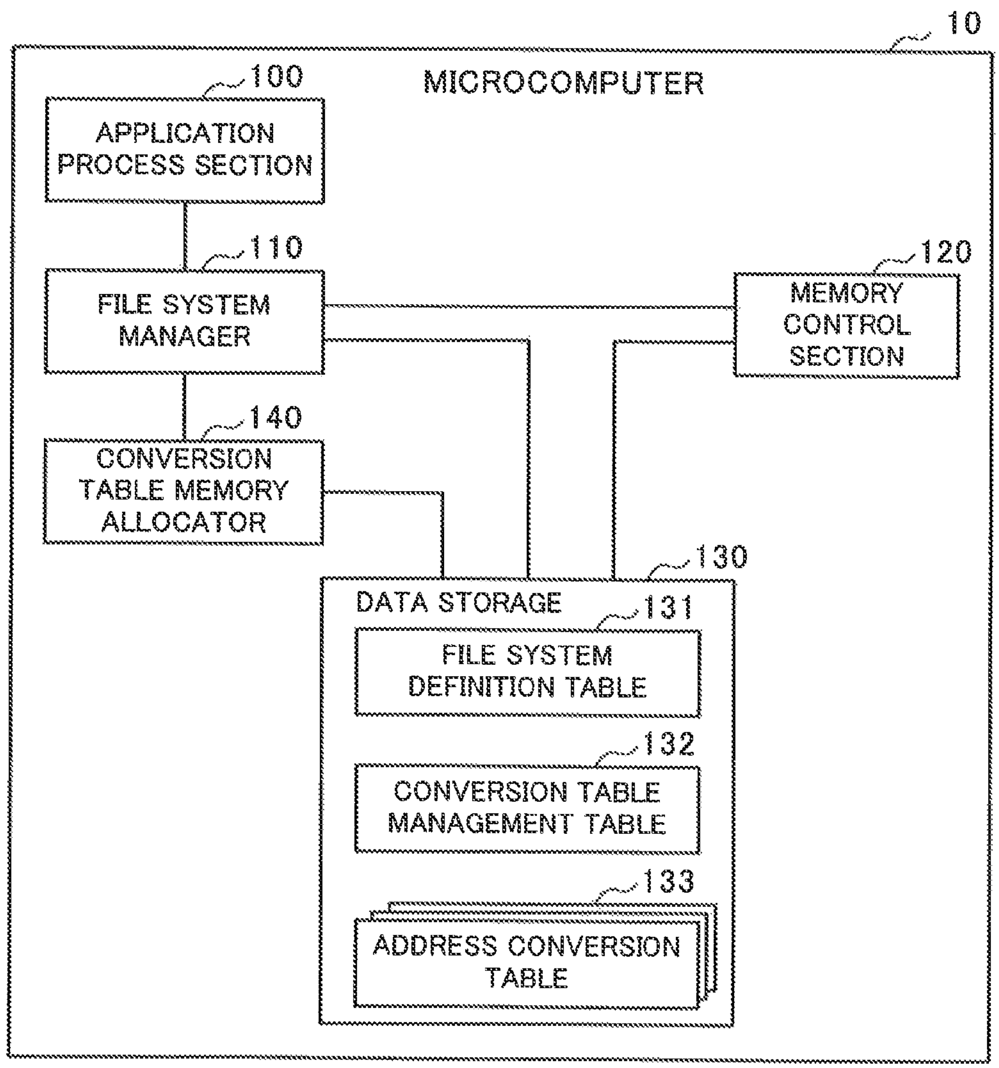
10
MICROCOMPUTER
100
APPLICATION PROCESS SECTION
110
FILE SYSTEM MANAGER
120
MEMORY CONTROL SECTION
140
CONVERSION TABLE MEMORY ALLOCATOR
130
DATA STORAGE
131
FILE SYSTEM DEFINITION TABLE
132
CONVERSION TABLE MANAGEMENT TABLE
133
ADDRESS CONVERSION TABLE

FIG.3

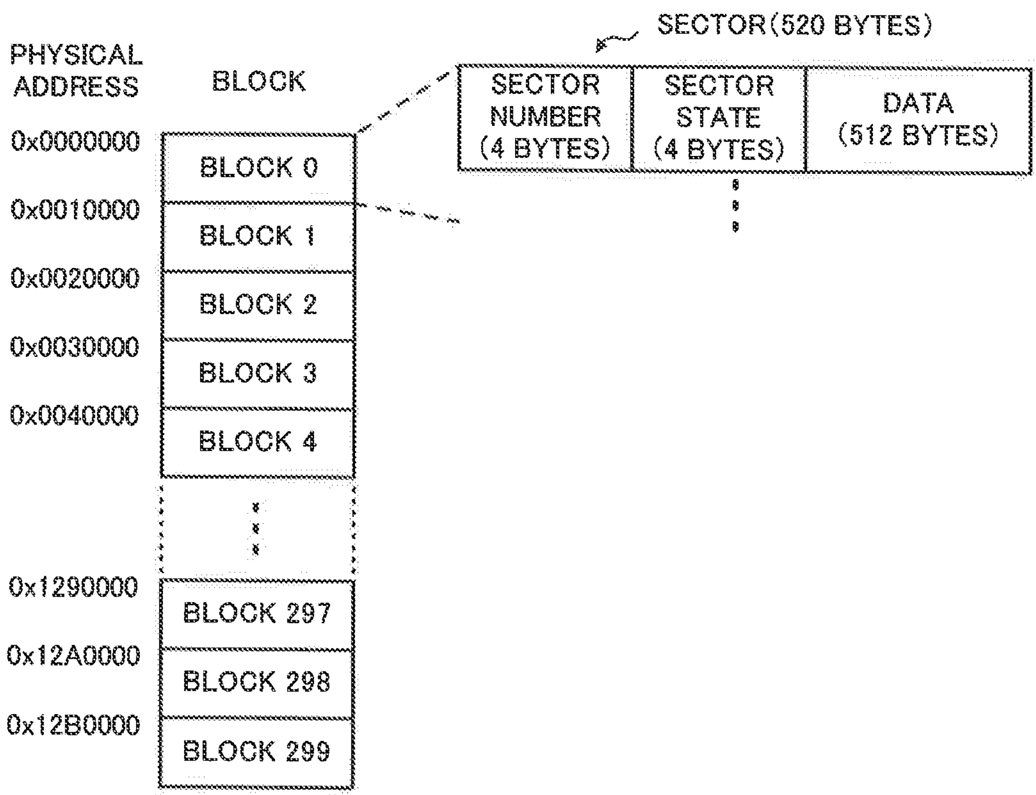

FIG.4

131

FILE SYSTEM DEFINITION TABLE	
START ADDRESS	0x0000000
START SECTOR	1
DRIVE SIZE	19.2MB

FIG.5

132

CONVERSION TABLE MANAGEMENT TABLE		
FILE NAME	FIRST ADDRESS	NUMBER OF RECORDS
"ABC.DAT"	...	...
"XYZ.DAT"	...	...

FIG.6

133

ADDRESS CONVERSION TABLE	
SECTOR NUMBER	PHYSICAL ADDRESS
21	0x0000208
22	0x0030410
⋮	⋮
1020	0x12B0000

FIG.7

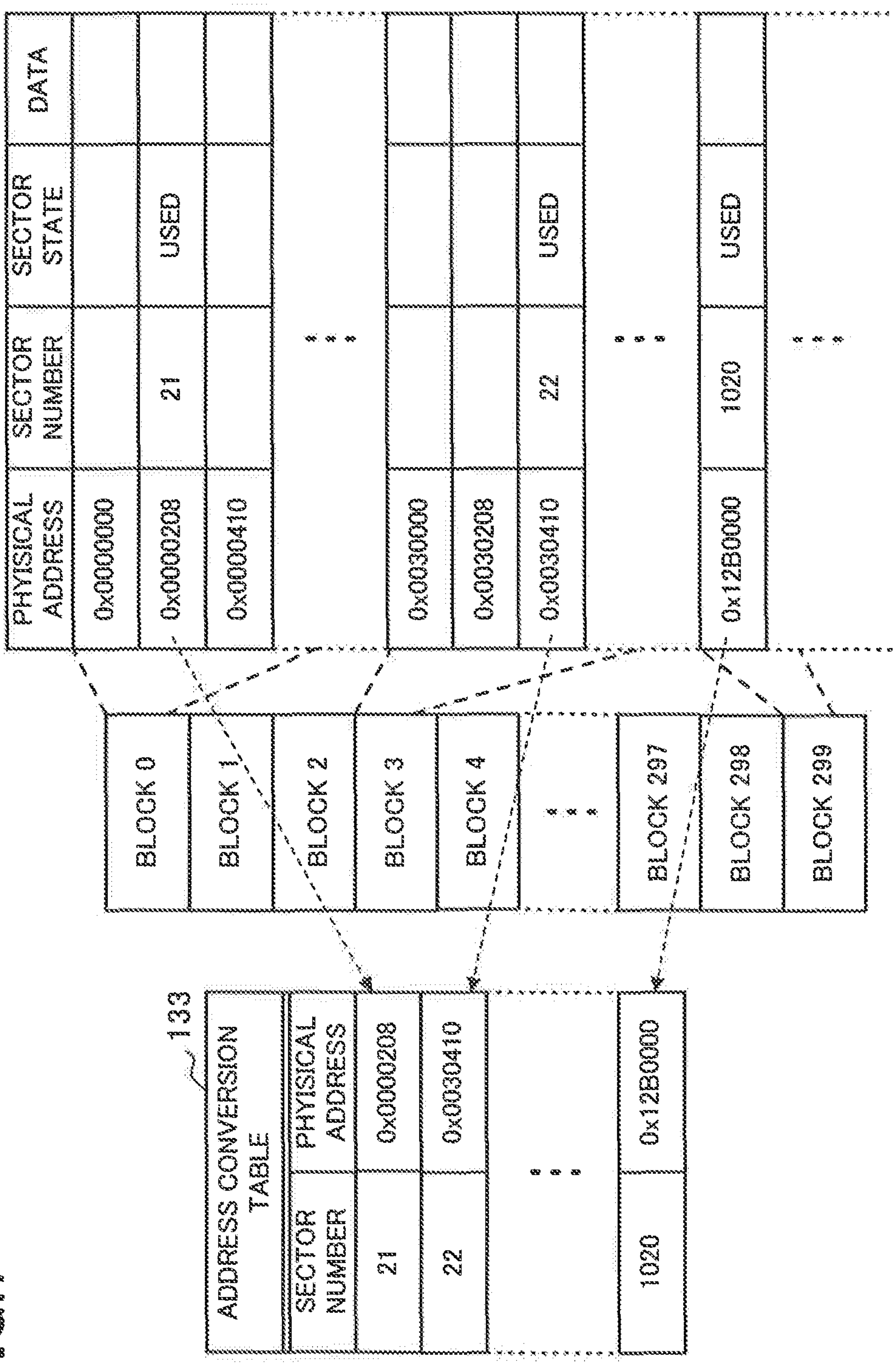
PHYSICAL ADDRESS
SECTOR NUMBER
SECTOR STATE
DATA
0x0000000
0x0000208
21
USED
0x0000410
0x0030000
0x0030208
0x0030410
22
USED
0x12B0000
1020
USED
BLOCK 0
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 297
BLOCK 298
BLOCK 299
133
ADDRESS CONVERSION TABLE
SECTOR NUMBER
PHYSICAL ADDRESS
21
0x0000208
22
0x0030410
1020
0x12B0000

FIG.8

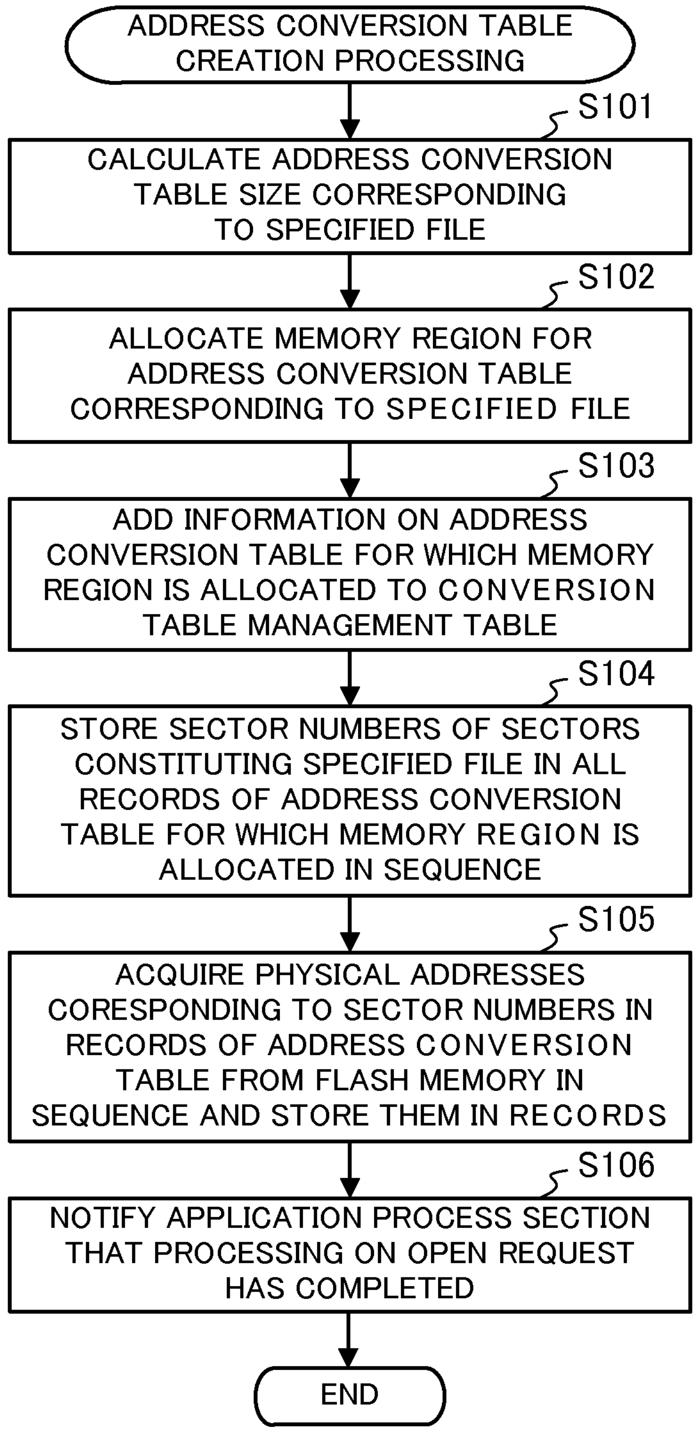
ADDRESS CONVERSION TABLE CREATION PROCESSING
S101
CALCULATE ADDRESS CONVERSION TABLE SIZE CORRESPONDING TO SPECIFIED FILE
S102
ALLOCATE MEMORY REGION FOR ADDRESS CONVERSION TABLE CORRESPONDING TO SPECIFIED FILE
S103
ADD INFORMATION ON ADDRESS CONVERSION TABLE FOR WHICH MEMORY REGION IS ALLOCATED TO CONVERSION TABLE MANAGEMENT TABLE
S104
STORE SECTOR NUMBERS OF SECTORS CONSTITUTING SPECIFIED FILE IN ALL RECORDS OF ADDRESS CONVERSION TABLE FOR WHICH MEMORY REGION IS ALLOCATED IN SEQUENCE
S105
ACQUIRE PHYSICAL ADDRESSES CORESPONDING TO SECTOR NUMBERS IN RECORDS OF ADDRESS CONVERSION TABLE FROM FLASH MEMORY IN SEQUENCE AND STORE THEM IN RECORDS
S106
NOTIFY APPLICATION PROCESS SECTION THAT PROCESSING ON OPEN REQUEST HAS COMPLETED
END

FIG.9

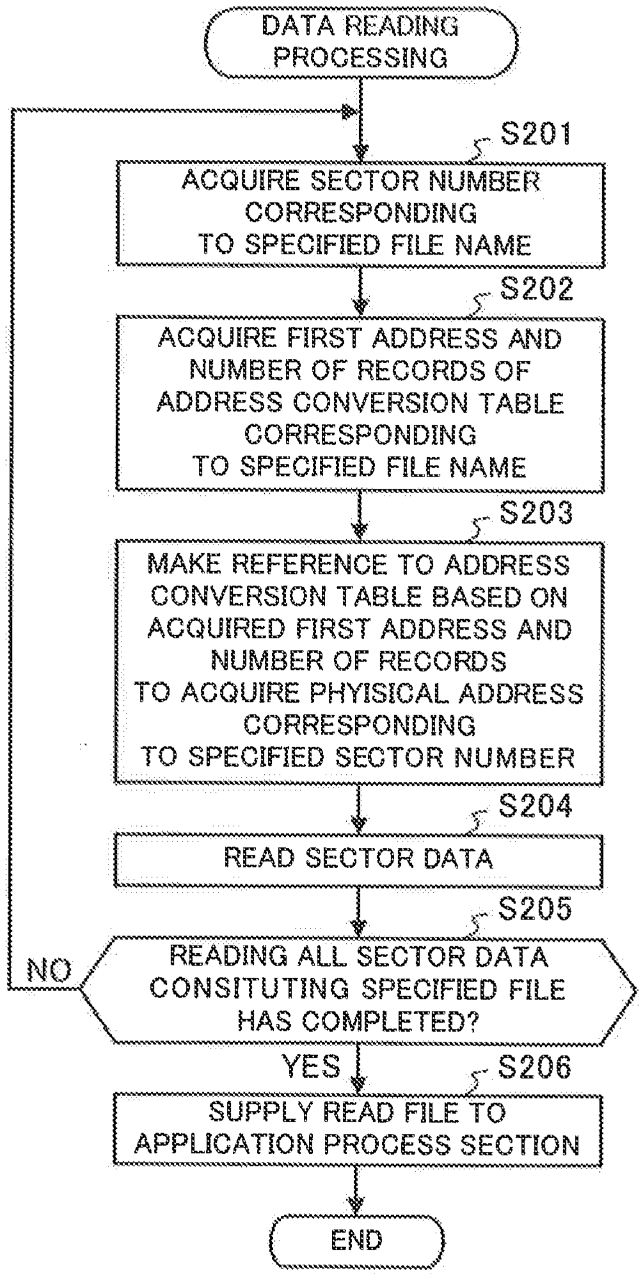
DATA READING PROCESSING
S201
ACQUIRE SECTOR NUMBER CORRESPONDING TO SPECIFIED FILE NAME
S202
ACQUIRE FIRST ADDRESS AND NUMBER OF RECORDS OF ADDRESS CONVERSION TABLE CORRESPONDING TO SPECIFIED FILE NAME
S203
MAKE REFERENCE TO ADDRESS CONVERSION TABLE BASED ON ACQUIRED FIRST ADDRESS AND NUMBER OF RECORDS TO ACQUIRE PHYISICAL ADDRESS CORRESPONDING TO SPECIFIED SECTOR NUMBER
S204
READ SECTOR DATA
S205
READING ALL SECTOR DATA CONSITUTING SPECIFIED FILE HAS COMPLETED?
NO
YES
S206
SUPPLY READ FILE TO APPLICATION PROCESS SECTION
END

FIG.10

131

FILE SYSTEM DEFINITION TABLE	
START ADDRESS	0x0000000
START SECTOR	1
DRIVE SIZE	19.2 MB
NUMBER OF OPEN RESERVATIONS	8
RESERVATION SIZE	60 B

MEMORY CONTROLLER

CROSS REFERENCE TO RELATED APPLICATION

This application is a U.S. national stage application of PCT/JP2011/051960 filed on Jan. 30, 2011.

TECHNICAL FIELD

The present invention relates to a technique of accessing a nonvolatile storage medium such as a flash memory.

BACKGROUND

Recently, flash memories, a nonvolatile storage medium, are used with various electronic devices such as information processing devices including personal computers, cellphones, and digital cameras. Also, various techniques for accessing a flash memory have been proposed in the prior art (for example, Patent Literature 1).

The memory card disclosed in Patent Literature 1 comprises a flash memory and a controller controlling the flash memory, wherein the controller can receives, from an external source, a command to write data in the direction that the address increases and detects the last writing position after the writing for the received command. The controller refers to a conversion table presenting the relationship between a sector and the corresponding physical address on a flash memory and searches for the physical address corresponding to the sector (logical data) on the flash memory.

Patent Literature 1: Unexamined Japanese Patent Application Kokai Publication No. 2006-40264.

However, the conversion table designed to make the physical address on a flash memory corresponding to a sector immediately known, as in the technique disclosed in the Patent Literature 1, grows in size as the flash memory size is increased. Therefore, it is not easy to use such a conversion table in a microcomputer system requiring a smaller memory or the like as in the prior art.

SUMMARY

The present invention is invented to solve the above prior art problem and an exemplary objective of the present invention is to provide a memory controller capable of accessing the physical address corresponding to a specified sector on a readable/writable storage medium such as a flash memory at a high speed while reducing the resident memory consumption.

In order to achieve the above objective, the memory controller according to the present invention comprises:

memory control means accessing a readable/writable nonvolatile memory and reading and writing data on the basis of a sector unit of a file system established for the nonvolatile memory;

a data storage that temporarily stores an address conversion table, in which one or multiple records comprising the sector number of a sector constituting a file stored on the nonvolatile memory and the physical address on the nonvolatile memory corresponding to the sector number are registered for each file;

memory allocation means allocating a memory region on the data storage for the address conversion table corresponding to a file when a request is made to open the file from an external source;

memory release means releasing the memory region allocated by the memory allocation means at a given time; and

sector number storing means storing sector numbers of at least some sectors constituting the file in each record of the address conversion table for which the memory region is allocated in sequence and notifying the memory control means accordingly after the storing, wherein:

the memory control means searches the nonvolatile memory to acquire a physical addresses corresponding to a sector number in the each record of the address conversion table and stores each acquired physical address in the corresponding record upon receiving the notification from the sector number storing means, and

makes reference to the address conversion table corresponding to a file using a sector number of a sector as the key to acquire a physical address corresponding to the sector in accessing the sector constituting the file.

Advantageous Effects of Invention

The present invention makes reference to an address conversion table associating a sector number with a physical address in accessing the sector so as to immediately acquire the physical address corresponding to the sector, whereby accessing a nonvolatile memory is expedited. Furthermore, the address conversion table temporarily occupies a memory region, whereby the resident memory consumption can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an illustration showing an entire configuration of a flash memory system comprising a microcomputer having a function of a memory controller according to an embodiment of the present invention;

FIG. **2** is a block diagram showing a configuration of the microcomputer in FIG. **1**;

FIG. **3** is an illustration schematically showing a memory structure of the flash memory in FIG. **1**;

FIG. **4** is an illustration showing an example of a file system definition table;

FIG. **5** is an illustration showing an example of a conversion table management table;

FIG. **6** is an illustration showing an example of an address conversion table;

FIG. **7** is an illustration for explaining a physical address setting processing;

FIG. **8** is a flowchart showing a procedure of an address conversion table creation processing;

FIG. **9** is a flowchart showing a procedure of a data reading processing; and

FIG. **10** is an illustration showing an example of a file system definition table used in another embodiment.

DETAILED DESCRIPTION

The memory controller according to an embodiment of the present invention will be described in detail hereafter with reference to the drawings.

FIG. **1** is an illustration showing the general configuration of a flash memory system **1** comprising a microcomputer **10** having the function of the memory controller according to this embodiment and a flash memory **20**. The microcomputer **10** and flash memory **20** are connected by a data bus **30**.

The microcomputer **10** is installed in various electronic devices or various electric appliances and controls the entire operation of the device. The microcomputer **10** comprises, from the viewpoint of hardware, a microprocessor, a ROM (Read Only Memory), a RAM (Random Access Memory), a memory interface, a clock source such as a quartz oscillator (none of the above is shown), and the like.

The microcomputer **10** functionally comprises, as shown in FIG. **2**, an application process section **100**, a file system manager **110**, a memory control section **120**, a data storage **130**, and a conversion table memory allocator **140**. The file system manager **110**, memory control section **120**, data storage **130**, and conversion table memory allocator **140** are in charge of the function of the memory controller in the present invention.

The application process section **100** executes processing according to various application software programs stored on the ROM or the like for realizing the function of the device. The file system manager **110** manages the file system established for the flash memory **20**. Furthermore, the file system manager **110** is in charge of the function of sector number storing means and memory releasing means in the present invention. The memory control section **120** accesses the flash memory **20** according to a request from the application process section **100** via the file system manager **110** to execute various kinds of processing (reading data, writing data and the like).

The data storage **130** stores various tables for defining the file system. In this embodiment, the data storage **130** stores a file system definition table **131**, a conversion table management table **132**, an address conversion table **133**, and the like. These tables will be described in detail later.

The memory region of the flash memory **20** is divided into multiple blocks as shown in FIG. **3**. A block (purging block) is the unit for deleting data. A sector, which is the unit for managing data in the file system, is a division of a block divided to a given size (for example, 520 bytes), comprising a "sector number" region (for example, 4 bytes), a "sector state" region (for example, 4 bytes), and a "data" region (for example, 512 bytes).

The "sector number" region stores a number assigned to each sector (a sector number) managed by the file system. In this embodiment, serial numbers starting from 1 are assigned to the sectors.

The "sector state" region stores information indicating the usage state of the sector (sector state). With reference to the "sector state" region, it is known that the sector is in one of the states "unused," "used" and "deleted." For example, immediately after a block is purged, all sectors in the block are "unused." The "data" region stores data corresponding to the sector number stored in the "sector number" region.

For accessing data stored on the flash memory **20** and corresponding to the sector number specified by the file system manager **110**, the memory control section **120** scans the memory region of the flash memory **20** on the basis of a sector unit (for example, 520 bytes) in sequence. Then, the memory control section **120** accesses the "data" region of the sector of which the "sector number" region stores the same sector number as the specified one and the "sector state" region stores information indicating "used." Furthermore, as described later, the memory control section **120** makes reference to the created address conversion table **133** using the sector number as the key to acquire the physical address corresponding to the specified sector number. Then, the memory control section **120** can immediately access the data stored on the flash memory **20** and corresponding to the specified sector number.

On the other hand, for writing new data (a file) on the flash memory **20**, the memory control section **120** allocates one or multiple "unused" sectors corresponding to the data size (file size) specified by the file system manager **110** and writes the data.

Furthermore, for overwriting data, the memory control section **120** writes data and a sector number in an "unused" sector different from the "used" sector corresponding to the specified sector number and changes the sector state to "used." Furthermore, the memory control section **120** changes the sector state of the original sector to "deleted."

The file system definition table **131** comprises, as shown in FIG. **4**, fields "start address," "start sector," "drive size," and the like.

The "start address" stores a first address of the memory region of the flash memory **20** (0x0000000 in this embodiment). The "start sector" stores a start sector number (1 in this embodiment). The "drive size" stores a maximum memory capacity of the flash memory **20** managed by the file system (19.2 MB (megabytes) in this embodiment).

The conversion table management table **132** is a data table presenting information regarding the address conversion tables **133** corresponding to files that are currently opened. The conversion table management table **132** comprises, as shown in FIG. **5**, fields "file name," "first address," "number of records," and the like.

The "file name" stores the name of a file currently opened. The "first address" stores a memory address on the data storage **130** indicating the beginning of the corresponding address conversion table **133**. The "number of records" stores the number of records of the address conversion table **133**. Here, if zero is stored in the "number of records," it means that the address conversion table **133** corresponding to the file has not been created for some reason such as memory shortage. In such a case, the "first address" stores a given value "NULL."

The address conversion table **133** is a data table associating the numbers of sectors (sector numbers) constituting a file currently opened with the physical addresses on the flash memory **20**. The address conversion table **133** is temporarily created for each of the currently opened files. As shown in FIG. **6**, the address conversion table **133** comprises multiple records including fields "sector number" and "physical address."

The address conversion table **133** is created after a memory region corresponding to the table size is allocated on the data storage **130**. The table size is determined based on the number of sectors constituting the corresponding file. More specifically, the table size is obtained by multiplying the number of sectors of the file by the record size (the size corresponding to the data type of the "sector number" (for example, 2 bytes)+the size corresponding to the data type of the "physical address" (for example, 4 bytes)). For example, if the number of sectors is four and the record size is six bytes, the size of the memory region allocated for the address conversion table **133** is 4×6=24 bytes.

In the above case, the number of sectors constituting a file is equal to the number of records of the address conversion table **133** corresponding to the file. If the data storage **130** does not have a sufficient free region, it is possible that the number of sectors is greater than the number of records in some cases. Furthermore, the address conversion table **133** itself corresponding to the file may not be created in some cases.

The conversion table memory allocator **140** allocates a memory for the address conversion table **133** on the data storage **130** according to a request from the file system manager **110**. In doing so, the file system manager **110** calculates the table size of the address conversion table **133** to allocate as described above and requests the conversion table memory allocator **140** to allocate a memory region using the table size as a parameter.

The conversion table memory allocator **140** checks on a given memory region on the data storage **130** and determines whether there is a free region of the required size. If there is a free region of the required size, the conversion table memory allocator **140** allocates a free region of the required size and returns a response message to the file system manager **110**, the response message comprising a response type indicating that a memory region of the required size is allocated and a first address of the allocated memory region.

On the other hand, if there is some free region but not of the required size, the conversion table memory allocator **140** allocates a memory region of the free region size. Then, the conversion table memory allocator **140** returns a response message including the response type indicating that a memory region of the required size is not allocated, the size of the allocated memory, and the first address of the allocated memory region to the file system manager **110**.

If there is no free region, the conversion table memory allocator **140** returns a response message including the response type indicating that there is no free region to the file system manager **110**.

Receiving the above response message from the conversion table memory allocator **140**, the file system manager **110** adds information regarding the address conversion table **133** corresponding to the file to the conversion table management table **132** (see FIG. **5**). More specifically, the file system manager **110** enters a record comprising the file name of the file and the first address and number of records of the address conversion table **133** in the conversion table management table **132**. Here, if some memory is allocated but the size of the allocated memory region is not of the required size, the file system manager **110** divides the size of the allocated memory region by the record size and employs the resultant quotient as the number of records in the address conversion table **133**.

Furthermore, if no memory region is allocated or the size of the allocated memory region is smaller than the record size, the file system manager **110** stores NULL in the “first address” and zero in the “number of records” of the record entered in the conversion table management table **132**.

After the above entry, the file system manager **110** executes the processing in sector number storing means in the present invention. In other words, the file system manager **110** stores the sector numbers of the sectors constituting the file in the “sector number” region of the records in the address conversion table **133** for which a memory region is allocated in sequence. Then, the file system manager **110** notifies the memory control section **120** of a request for the processing of filling the “physical address” region of the records in the address conversion table **133**. In other words, the file system manager **110** requests the memory control section **120** to execute a procedure for searching the flash memory **20** to acquire the physical addresses corresponding to the sector numbers in the records and storing the physical addresses in the “physical address” region of the records (the physical address setting processing).

In doing so, the file system manager **110** requests the memory control section **120** to execute the physical address setting processing using the file name of the file as a parameter. Receiving the request, the memory control section **120** makes reference to the conversion table management table **132** and acquires the first address and number of records of the address conversion table **133** corresponding to the specified file name. The memory control section **120** retrieves the sector numbers in sequence starting from the first record of the address conversion table **133** based on the acquired first address and number of records.

The memory control section **120** accesses the flash memory **20** and starts scanning on the basis of a sector unit (for example, 520 bytes) downward (toward the rear blocks) from the first address (0x0000000 in this embodiment) stored in the “start address” region of the file system definition table **131** in sequence. In this scanning, the memory control section **120** searches for a sector having the same sector number and being “used.” If the sector is found in the search, the memory control section **120** acquires the physical address of the sector and stores the physical address in the “physical address” region of the record in the address conversion table **133**.

The memory control section **120** repeats the above processing and stores the corresponding physical addresses in all records of the address conversion table **133** as shown in FIG. **7**. After the physical addresses are stored in all records, the memory control section **120** notifies the file system manager **110** of the status that the physical address setting processing ends.

The address conversion table **133** corresponding to each of the currently opened files is created as described above. As the address conversion table **133** is created, the memory control section **120** makes reference to the address conversion table **133** when the file system manager **110** makes a request for accessing (reading or the like) a sector of the file. Then, the corresponding physical address on the flash memory **20** can immediately be accessed, whereby the processing is expedited. Here, if “the total number of sectors constituting a file” is greater than “the number of records of the address conversion table **133**,” some sector numbers may not be stored in the address conversion table **133**. In such a case, the memory control section **120** scans the memory region of the flash memory **20** on the basis of a sector unit, in sequence, in a conventional manner to access the required sector.

The created address conversion table **133** is deleted by the file system manager **110** as the corresponding file is closed. In other words, the memory region for the address conversion table **133** is released. Furthermore, the corresponding record of the conversion table management table **132** is also deleted.

If a request is made to write (overwrite) the file after the address conversion table **133** has been created, the memory control section **120** updates the physical addresses in all records of the address conversion table **133** to the physical addresses of the respective destination sectors.

FIG. **8** is a flowchart showing a procedure of an address conversion table creation processing executed by the cooperation of the file system manager **110**, conversion table memory allocator **140**, and memory control section **120**.

The address conversion table creation processing starts as the application process section **100** notifies the file system manager **110** of a file opening request. Here, the application process section **100** specifies the name of a file to open (a file name) in the opening request.

Receiving the file opening request from the application process section **100**, the file system manager **110** makes reference to a not-shown file information table to acquire the size corresponding to the specified file name (the file size). The file information table is a table associating a file name, a file size, the numbers of the sectors (the sector numbers) constituting the file, and the like. The file information table is created when the file is written to the flash memory **20** for the first time and stored on the data storage **130**.

The file system manager **110** calculates the table size of the address conversion table **133** to allocate based on the acquired file size (Step S**101**). Then, the file system manager **110** requests the conversion table memory allocator **140** to allocate a memory region using the table size as a parameter.

The conversion table memory allocator **140** allocates a memory region for the address conversion table **133** as described above (Step S**102**), and replies to the file system manager **110** with the results.

Receiving the reply, the file system manager **110** adds information regarding the address conversion table **133** corresponding to the file to the conversion table management table **132** (see FIG. **5**) (Step S**103**).

The number of records of the address conversion table **133** added to the conversion table management table **132** is, as described above, equal to the number of sectors constituting the file if a memory region of the required table size is allocated. However, the number of records is less than the total number of all sectors if the size of the allocated memory region is smaller than the required table size. For example, if the size of the allocated memory region is 1 KB (kilobyte) and the record size of the address conversion table **133** is six bytes, the number of records is 170 (1024/6). Furthermore, if no memory is allocated or the size of the allocated memory region is smaller than the record size, zero is stored in the "number of records" region and NULL is stored in the "first address" region.

Then, the file system manager **110** stores the sector numbers of the sectors constituting the file in all records of the address conversion table **133** for which a memory region is allocated in sequence (Step S**104**). However, this processing is executed only when a memory region equal to or larger than one record (for example, 6 bytes) is allocated.

Then, the file system manager **110** requests the memory control section **120** to execute the physical address setting processing. However, this processing is also executed only when a memory region equal to or larger than one record is allocated like the above processing.

The memory control section **120** searches the memory region of the flash memory **20** to acquire the physical addresses corresponding to the sector numbers in all records of the address conversion table **133** and stores the physical addresses in the corresponding records (Step S**105**).

After completing the physical address setting processing, the memory control section **120** notifies the file system manager **110** accordingly. Receiving the notification, the file system manager **110** notifies the application process section **100** that the processing on the opening request has completed (Step S**106**).

The address conversion table **133** corresponding to the file requested to open is created as described above.

The processing executed when the application process section **100** makes a request for reading the file after the address conversion table **133** is created will be described hereafter. FIG. **9** is a flowchart showing the procedure of the data reading processing executed by the file system manager **110** and memory control section **120**. The data reading processing starts as the application process section **100** notifies the file system manager **110** of a data reading request. Here, the application process section **100** specifies the name of a file to read (a file name) in the data reading request.

The file system manager **110** makes reference to the above-mentioned file information table to acquire the sector number corresponding to the specified file name (Step S**201**). Here, when the file comprises multiple sectors, the file system manager **110** acquires the corresponding sector numbers one at a time in sequence with reference to the file information table.

The file system manager **110** notifies the memory control section **120** of the acquired sector number and the file name of the file, and requests the memory control section **120** to read the data corresponding to the sector.

Receiving the request, the memory control section **120** makes reference to the conversion table management table **132** to acquire the first address and number of records of the address conversion table **133** corresponding to the specified file name (Step S**202**). The memory control section **120** checks on the value stored in the "sector number" region in sequence starting from the first record of the address conversion table **133** based on the acquired first address and number of records, and searches for the record where the specified sector number is stored. Then, the memory control section **120** acquires the physical address stored in the "physical address" region of the record (Step S**203**).

The memory control section **120** accesses the sector located at the acquired physical address on the flash memory **20** and reads the data stored in the "data" region (sector data) (Step S**204**). The memory control section **120** supplies the read sector data to the file system manager **110** and notifies the file system manager **110** that reading the sector data has completed. Receiving the notification, the file system manager **110** determines whether reading all sector data constituting the file has completed (Step S**205**).

If reading all sector data has not completed (Step S**205**; NO), the above processing is repeatedly executed. In other words, the file system manager **110** makes reference to the file information table to acquire the next corresponding sector number (Step S**201**). Then, the file system manager **110** notifies the memory control section **120** of the acquired sector number and the file name of the file, and requests the memory control section **120** to read the data corresponding to the sector. Receiving the request, the memory control section **120** executes the processing in the above Steps S**202** to S**204**.

On the other hand, after reading all sector data has completed (Step S**205**; YES), the file system manager **110** supplies all read sector data, namely the read file, to the application process section **100** (Step S**206**), and the processing ends.

As described above, when a file is opened, the microcomputer **10** (memory controller) in this embodiment creates an address conversion table **133** associating the numbers of the sectors constituting the file with the physical addresses on the flash memory **20**. Then, when a request is made to read the file or the like while the file is opened, the sector stored on the flash memory **20** and corresponding to the specified sector number can immediately be accessed by making reference to the address conversion table **133**. Then, the processing is expedited.

Furthermore, the memory region for the address conversion table **133** is allocated when a file is opened and released when the file is closed. Therefore, the table is not normally present on the data storage **130** and the memory region is temporarily occupied. Therefore, the resident memory consumption can be reduced.

The present invention is not confined to the above embodiment and various changes can be made without departing from the gist of the present invention.

For example, in the above embodiment, the memory region allocated for the address conversion table **133** is released when the corresponding file is closed. However, the time to release the memory region is not limited thereto. For example, the memory region may be released after a given time period has elapsed since the allocation. In this way, a single memory region allocated for the address conversion table **133** is not occupied for a prolonged time.

Furthermore, in the above embodiment, the conversion table memory allocator **140** allocates a memory region of the required size if a free region of the required size is available on the data storage **130**. The way of allocating a memory region is not limited thereto. For example, a memory region may be allocated in consideration of files to be opened later. More specifically, in such a case, as shown in FIG. **10**, the file system definition table **131** additionally comprises fields "number of open reservations" and "reservation size."

The "number of open reservations" field stores a predicted number of files opened simultaneously. "The files opened simultaneously" means that a file is opened and another file is opened before the one file is closed. The predicted number can be a predetermined fixed value or a value updated as appropriate such as the average or maximum number of files opened simultaneously in the past.

Furthermore, the "reservation size" field stores the minimum size guaranteed to be allocated for an address conversion table **133** even if files as many as the number stored in the "number of opening reservations" field are opened simultaneously. The size can be a fixed value or a value updated as appropriate such as the average or maximum value of the sizes of the address conversion tables **133** created in the past.

In the above case, receiving a memory region allocating request from the file system manager **110**, the conversion table memory allocator **140** determines the maximum allocable memory region size based on the free region size on the data storage **130**, the values stored in the "number of open reservations" field and "reservation size" field of the file system definition table **131**, and the number of currently opened files.

For example, if the "number of open reservations" is eight and two files are currently opened including itself, six more files can be opened later. In such a case, if the "reservation size" is 60 B (bytes), the maximum size allocable for the address conversion table **133** is determined by subtracting 360 B (6.times.60 B) from the free region size.

In this way, even if multiple files are opened simultaneously, the problem that the address conversion table **133** cannot be created for a file requested to open later because of memory shortage can be prevented. Then, the file requested to open later is prevented from significantly slowing down in processing.

Furthermore, it is possible that the application process section **100** is able to specify the priority of a file to open and the maximum allocable memory region size is determined according to the priority. In such a case, for example, the conversion table memory allocator **140** allocates a memory region of the required size for a high-priority file if there is a free region of the required size on the data storage **130**. On the other hand, the conversion table memory allocator **140** allocates a memory region of a given size smaller than the required size (for example, a size stored in the "reservation size" field) for a low-priority file even if there is a free region of the required size on the data storage **130**.

In this way, the address conversion table **133** of a desired size can be created for a high-priority file (for example, a file with which a reading request or the like is often issued while the file is opened), whereby the processing is efficiently expedited.

Various embodiments and modifications are available to the present invention without departing from the broad sense of spirit and scope of the present invention. The above-described embodiment is given for explaining the present invention and do not confine the scope of the present invention. In other words, the scope of the present invention is set forth by the scope of claims, not by the embodiments. Various modifications made within the scope of claims and scope of significance of the invention equivalent thereto are considered to fall under the scope of the present invention.

INDUSTRIAL APPLICABILITY

The present invention can preferably be used in various electronic devices using readable/writable storage media such as flash memories.

The invention claimed is:

1. A memory controller, comprising:

a memory control section that accesses a readable/writable nonvolatile memory and reads and writes data on the basis of a sector unit of a file system established for the nonvolatile memory;

a data storage that temporarily stores an address conversion table for each file;

a memory allocator that allocates a memory region on the data storage for the address conversion table corresponding to a file when a request is made to open the file from an external source;

a memory releaser that releases the memory region for the address conversion table allocated by the memory allocator at a given time; and

a sector number storer that sequentially stores sector numbers of at least some sectors constituting the file in each record of the address conversion table for which the memory region for the address conversion table is allocated and notifies the memory control section accordingly after the storing, wherein:

the memory control section searches the nonvolatile memory to acquire a physical address corresponding to a sector number in each record of the address conversion table and stores each acquired physical address in the corresponding record upon receiving the notification from the sector number storer, and

makes reference to the address conversion table corresponding to a file using a sector number of a sector as the key to acquire a physical address corresponding to the sector in accessing the sector constituting the file.

2. The memory controller according to claim **1**, wherein the memory releaser releases the memory region for the address conversion table corresponding to a file when a request is made to close the file.

3. The memory controller according to claim **1**, wherein the memory releaser releases the memory region for the address conversion table after a given time period has elapsed since the memory region was allocated.

4. The memory controller according to claim **1**, wherein the sector number storer stores the sector numbers of all sectors constituting a file in the address conversion table when the number of records of the address conversion table developed on the memory region allocated by the memory allocator is equal to or greater than the total number of sectors constituting the file.

5. The memory controller according to claim **1**, wherein when there is a free region equivalent to a memory region for the address conversion table corresponding to the total number of sectors constituting the file in a given memory region of the data storage, the memory allocator allocates the free region for the memory region for the address conversion table.

6. The memory controller according to claim **1**, wherein the memory allocator allocates a memory region for the address conversion table in consideration of the number of files to be opened later.

7. The memory controller according to claim 1, wherein the file is given a given priority, and

the memory allocator allocates a memory region for the address conversion table in consideration of the priority of a file requested to be opened.

8. A memory access method, comprising:

a memory control step that accesses a readable/writable nonvolatile memory and reads and writes data on the basis of a sector unit of a file system established for the nonvolatile memory;

a memory allocation step that allocates a memory region on a data storage for an address conversion table corresponding to a file when a request is made to open the file from an external source;

a memory release step that releases the memory region for the address conversion table allocated in the memory allocation step at a given time; and

a sector number storing step that sequentially stores sector numbers of at least some sectors constituting the file in each record of the address conversion table for which the memory region for the address conversion table is allocated,

wherein in the memory control step,

after the sector number storing step, a physical address corresponding to a sector number in each record of the address conversion table is acquired by searching the nonvolatile memory and each acquired physical address is stored in the corresponding record, and

in accessing a sector constituting a file, the physical address corresponding to the sector is acquired by making reference to the address conversion table corresponding to the file using the sector number of the sector as the key.

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